KING COUNTY CONVEYANCE SYSTEM IMPROVEMENT PROJECT

CONVEYANCE SYSTEM COST SYSTEM PUMP STATION COST PARAMETERS

FINAL REPORT

SEPTEMBER 2001

in association with

Brown and Caldwell

and

Herrara Environmental

INTRODUCTION

The purpose of this memo (originally written in 1999) is to define the parameters and cost estimation methodology for estimating pump station costs that are typical of standard King County Wastewater Treatment Division (KCWTD) designs. This memo covers the method to be used for estimating pump station construction costs. A more general discussion of the purpose of the model is included in the September 2001 *Conveyance System Cost Estimates – Task 250 Report.*

COST MODEL

The model will be structured to provide the user with a formatted means of data entry and a formatted output for incorporation into other cost estimating models. The relationship between the scope of this work and other cost models is detailed in the Figure 1.

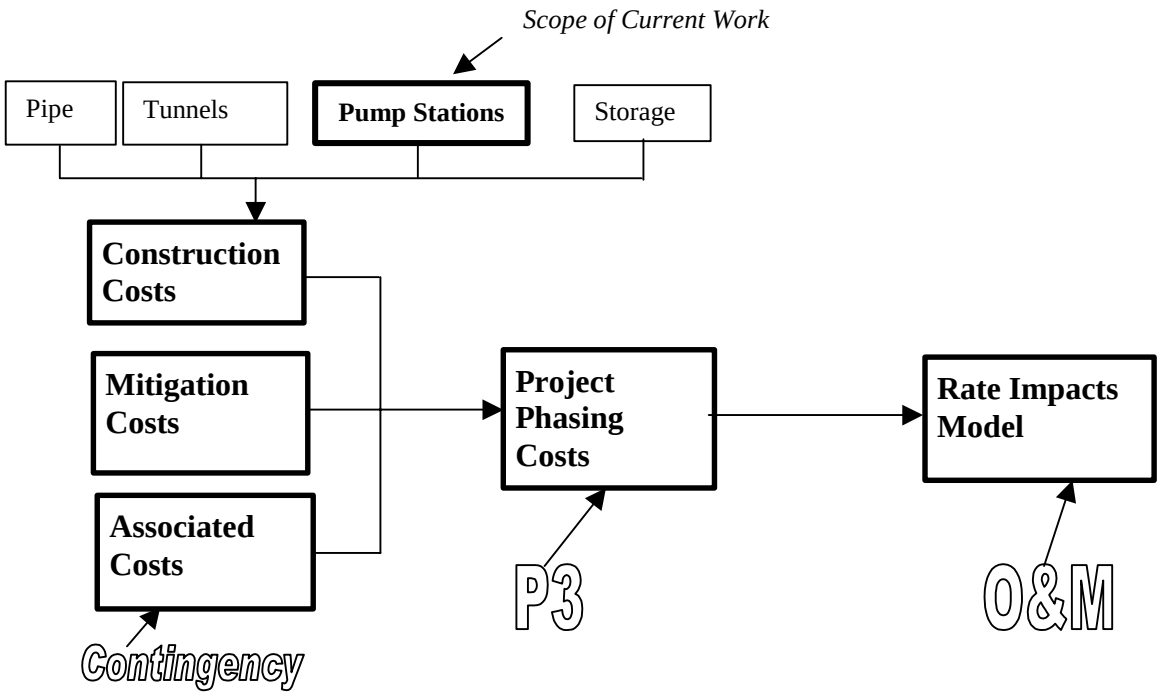

Figure 1. Cost Development Relationships

PUMP STATION COST MODULE

The construction costs of pump stations are influenced by a number of factors including the capacity of the pump station, the excavated depth for the pump station, the total dynamic head (TDH) of the pumps, and the inclusion or exclusion of certain elements such as an emergency generator, odor control unit (OCU), and chemical feed to minimize sulfide generation in the discharge from the pump station. The construction of pump stations varies significantly depending upon the inclusion or exclusion of these items. To provide some uniformity of approach to the cost estimates, the following assumptions were made regarding the inclusion and exclusion of some specialized equipment for the pump station:

The following elements are included in the costs elements developed:

- An architecturally treated superstructure;
- An activated carbon odor control unit;
- Variable frequency drives for the raw wastewater pumps;
- Separate wet well and drywells;
- Chemical feed for odor and corrosion control; and
- Standby generator power supply for the firm pump station capacity.

The following elements are not included:

- Trash racks and/or mechanically cleaned bar screens;
- Natural gas driven pumps; or
- Comminutors.

The most accurate way to estimate the cost of a pump station is to develop a conceptual design and estimate the cost of the structure and equipment for the conceptual design. However, this approach is similar to a predesign estimate that may be more detailed or impractical for projects at the initial planning stages. The purpose of this module is to bridge the gap between initial planning level estimates based solely on the pump station capacity and more detailed predesign and design estimates based on a specific pump station design.

User Input Parameters

The model is configured to allow the user to adjust the size, excavation depth, and pump TDH (Table 1). In some cases, there will be construction costs that are unique to a given project. These construction costs may include land acquisition and demolition of existing structures. To account for these costs at the planning stage, the user will be allowed to input

a fixed dollar amount that will be calculated separately by the user. An input box will also be provided for describing the items included in these project specific construction costs.

Land acquisition costs will vary significantly depending upon the parcel to be acquired. As a rough guide, the costs for land acquisition can be estimated by locating the parcel at the King County Department of Development and Environmental Services website at http://www.metrokc.gov/ddes/property.htm. Past KCWTD estimates have included a land acquisition and management contingency of 45 percent and it is recommended that this management and acquisition contingency be added to the land and improvements costs of any parcel to be acquired.

Table 1: Project Specific Input Parameters

Parameter	Options	Default
Pump Station Name	User must input pump station name	Must be input by user
Construction Year	User may select future construction year	Current Year
Firm Capacity (mgd)	5-80 mgd	Must be input by user
TDH (ft)	20-400 feet	Must be input by user
Ground Surface Elevation (ft)	Greater than 0	Must be input by user
Influent Pipe Invert Elev. (ft)	Grater than 0 and greater than the GS Elev	Must be input by user
Unique Construction Costs	User must input a cost number and describe unique construction cost items	0

Cost Estimate Methodology

Several KCWTD pump station designs and the associated cost estimates for pump stations constructed in the past 10 years were reviewed to develop planning-level cost curves for this module. Additionally, the design and costs for some KCWTD pump stations built in the 1960s and 1970s were also reviewed. However, these older pump stations were frequently constructed without OCUs, emergency generators, and other equipment that is now standard in newer pump stations. For this reason, the inflation-adjusted cost of most older pump stations tend to be significantly less than more modern pump stations of similar capacities.

The design and cost estimates for three pump stations, North Creek, West Seattle, and Interurban, were used to develop cost curves for this module. The cost estimates for each pump station were itemized based on the various disciplines involved and CSI specification sections. These four disciplines used in the development of the cost curves were:

- Site/Civil – yard piping, paving, landscaping, fencing, and drainage.

- Electrical and Instrumentation – power, lighting, PLCs and SCADA system, standby generator including diesel storage tank and appurtenances, and automatic transfer switch.

- Architectural/Structural – shoring, excavation, backfill, concrete, reinforcement, masonry, doors, louvers, windows, grating, and finishes.

- Mechanical – pumps, motors, valves, interior piping, gates, flow meters, instrument air systems, chemical feed systems, odor control units, and HVAC equipment.

Site/civil cost estimates appeared to be linearly related to the firm pump station capacity in accordance with the equation:

$$\text{Site/Civil Cost (\$)} = \$20{,}000 \times \text{Capacity (mgd)} + \$85{,}000$$

There was a similarly linear relationship between the required pump horsepower for a pump station and the estimated electrical and instrumentation costs that include the emergency generator and associated equipment. The equation for electrical and instrumentation costs is:

$$\text{Electrical/Instrumentation Cost (\$)} = \$1{,}500 \times \text{Required Pump Power (Hp)} + \$314{,}000$$

The architectural/structural costs per mgd decreased in relation to increases in the pump station capacity. The "economy of size" relationships for the architectural/ structural and mechanical costs for the pump stations are:

$$\text{Architectural/Structural Cost (\$/mgd)} = \$0.42 \times \text{Capacity (mgd)}^{-0.47} \times 10^6$$

The unit architectural/structural costs were adjusted to accommodate for deeper and shallower excavations as well a slight increase in costs for higher head pump stations to accommodate the slightly larger mechanical equipment in these cases. The formula for the adjustment is:

$$\text{Architectural/Structural Adjustment (\$/mgd)} =$$
$$\$0.20 \times \left[\left(\frac{\text{Excavation depth (ft)} - 30}{30} \right) + 0.01 \times \left(\frac{\text{TDH (ft)} - 120}{120} \right) \right] \times 10^6$$

As with the architectural/structural unit costs, the mechanical unit costs for pump stations decreased with increasing pumping capacity due to economy of scale and where adjusted to reflect changes in the total dynamic pumping head. The equations to develop and adjust the units costs are:

$$\text{Base Mechanical Cost (\$/mgd)} = \$0.33 \times \text{Capacity (mgd)}^{-0.43} \times 10^6$$

$$\text{Mechanical Adjustment (\$/mgd)} = \begin{cases} \$0.05 \times \dfrac{\text{TDH (ft)} - 120}{120} \times 10^6 \text{ for TDH} < 300 \\ 1.2 \times \text{Base Mechanical Cost (\$/mgd) for TDH} \geq 300 \end{cases}$$

The cost curves and the supporting data used to generate these curves are provided in Appendix A.

These cost curves and adjustment factors were then used to estimate the costs for a number of King County pump stations built within the past 10 years. The cost estimates for the pump stations were within ±38 percent of the actual pump station costs adjusted to an ENR Seattle CCI of 7,137 to reflect December 1999 costs. These cost estimates and notes as to why the actual and estimated costs are different, are summarized in Table 2.

Table 2: Cost Estimates for Recently Constructed King County Pump Stations

Pump Station	Estimated Cost[1]	Actual Cost[1]	Percent Difference	Notes
Richmond Beach	$5,870,000	$8,711,000	-33%	Has mechanically cleaned bar screens and a room for this equipment.
Medina	$3,372,000	$2,445,000	38%	Reduced superstructure above the wetwell.
North Mercer	$3,647,000	$4,137,000	-12%	
West Seattle	$8,419,000	$7,118,000	18%	Excavation by others.
North Creek	$11,027,000	$9,848,000	12%	
Interurban	$8,909,000	$7,099,000	25%	Generator only sized to run 2 pumps.

Notes:
(1) Costs based on ENR Seattle CCI = 7,137 for December 1999.

The accuracy of the proposed model is a significant improvement over using a simple best fit curve for King County pump stations in which costs varied by –51 percent to +62 percent of the actual costs as shown in Table 3.

Table 3: Cost Estimates Using the Linear Best-Fit Approach

Pump Station	Firm Capacity (mgd)	Linear Best-Fit Estimate[1]	Actual Cost[1]	Percent Difference
Richmond Beach	10.0	$4,302,000	$8,711,000	-51%
Medina	7.2	$3,250,000	$2,445,000	33%
North Mercer	6.0	$2,799,000	$4,137,000	-32%
West Seattle	19.0	$7,683,000	$7,118,000	8%
North Creek	36.0	$14,068,000	$9,848,000	43%
Interurban	29.2	$11,514,000	$7,099,000	62%

Notes:
(1) Costs based on ENR Seattle CCI = 7,137 for December 1999.

Outputs

The output from the model will summarize the input parameters and model outputs in a spreadsheet format that can be exported into other King County cost model components.

APPENDIX A
PUMP STATION COST MODEL CURVES AND SUPPORTING DATA